

3DGENCE SUPPORT MATERIALS

GOOD PRACTICES

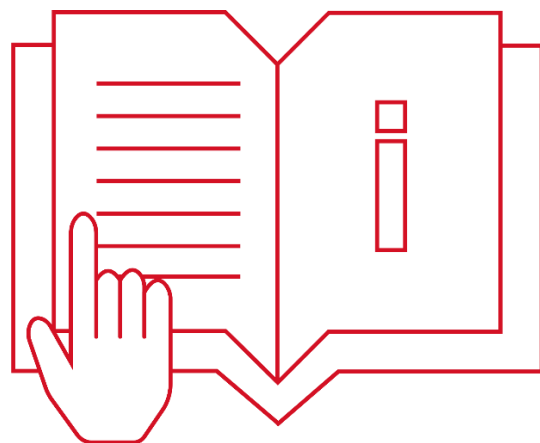


Table of Contents

1. INTRODUCTION.....	3
2. BREAKAWAY AND RINSE-OFF SUPPORTS	3
2.1. Definitions.....	3
2.2. Summary of materials.....	4
2.3. Selection of suitable support material.....	4
3. BREAKAWAY SUPPORTS.....	6
4. RINSE-OFF SUPPORTS	6
4.1. BVOH.....	7
4.1.1. Basic material data	7
4.1.2. Required equipment.....	7
4.1.3. Safety measures.....	7
4.1.4. Dissolving process.....	8
4.1.5. Disposal of the solution	8
4.1.6. Use and storage of material	8
4.2. ESM-10.....	9
4.2.1. Basic material data	9
4.2.2. Required equipment.....	9
4.2.3. Safety measures.....	11
4.2.4. Preparation of the solution.....	11
4.2.5. Dissolving process.....	12
4.2.6. Rinsing and drying of the model	13
4.2.7. Disposal of the solution	14
4.2.8. Station cleaning	14
4.2.9. Storage of material	14

1. INTRODUCTION

The FFF (Fused Filament Fabrication) technology employed in the 3DGence printers is based on the principle of depositing a thermoplastic plastic, layer by layer, on the working platform, thus bonding it with the previous layers. The specificity of this technology requires the use of additional support structures. The supports are broken off or dissolved, depending on the selected material. In 3DGence printers, support structures can be printed from the same hotend as the target model or from an additional dedicated hotend for dual-hotend printers. Before starting the printing process, appropriate support material suited to the model geometry should be selected. This will allow for easy separation of the applied support structures from the model after the print process has been completed. The supports should be removed in a way that does not damage the model.

2. BREAKAWAY AND RINSE-OFF SUPPORTS

2.1. Definitions

Breakaway supports are types of structures that are removed manually with the use of appropriate tools. Breakaway support materials are used in models with simple geometry, which do not require the use of complex support structures. This type of supports can be printed from the same material as the target model (in the case of single-hotend printers) or from another, characterized by less adhesion to the model, which significantly facilitates their removal (in the case of dual-hotend printers). An example of printed models with a breakaway support is shown in Fig. 1 and Fig. 2.



Fig. 1 Model printed from ABS model material and HIPS support material



Fig. 2 Model printed from PLA model material and PLA support material

Soluble supports are a type of structures made of dedicated support material, other than the model one, which can be dissolved by immersing the printout in water or in solution. They are used in dual-hotend printers, especially when printing models with complex geometry, where it is impossible or difficult to remove the supports mechanically. An example of a printed model with a soluble support made of BVOH material is shown in Fig. 3 and a model with a soluble support from ESM-10 is shown in Fig. 4.



Fig. 3 Model printed from PLA material model and BVOH support material



Fig. 4 Model printed from PEEK material model and ESM-10 support material

2.2. Summary of materials

Depending on the type of model material, breakaway or soluble supports can be used. The summary of mutually compatible 3DGence materials as of 07.12.2018 is presented in Table 1.

Table 1 Summary of compatible materials

Base material	Breakaway material	Soluble material
ABS	HIPS-X, ABS	ESM-10
Smart ABS	HIPS-X	-
PLA	PLA	BVOH
ASA	HIPS-X	-
PET	HIPS-X, PET	BVOH
PET-G	PET-G	-
PP	HIPS-X, PP	BVOH
CoPa Polymide (Nylon)	ABA	-
PC	ABS	-
PC-ABS	ABS	-
CF-PC	ABS	-
ESD-PC	ABS	-
PEEK	Dedicated support material	ESM-10
Fiberflex 40D	Fiberflex 40D	-
Primalloy	Primalloy	-
HIPS-X	HIPS-X	-

2.3. Selection of suitable support material

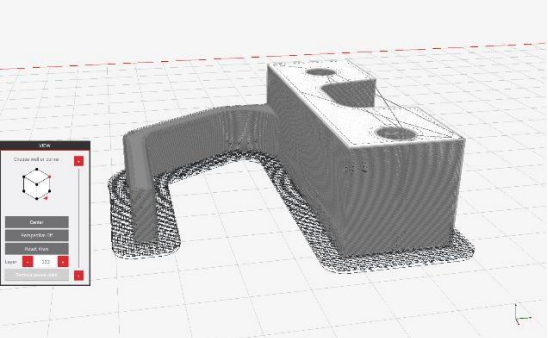
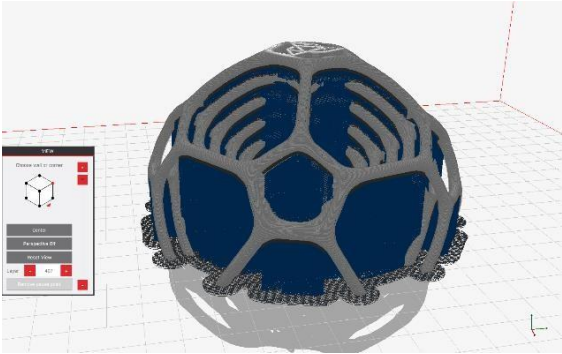
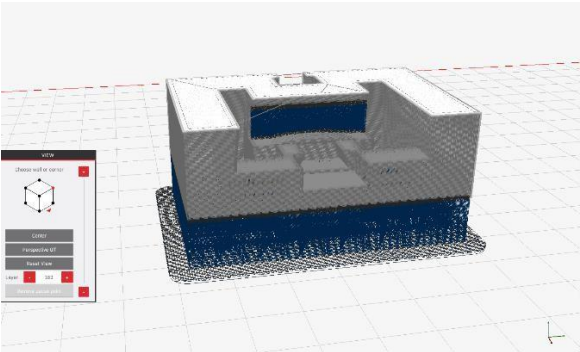
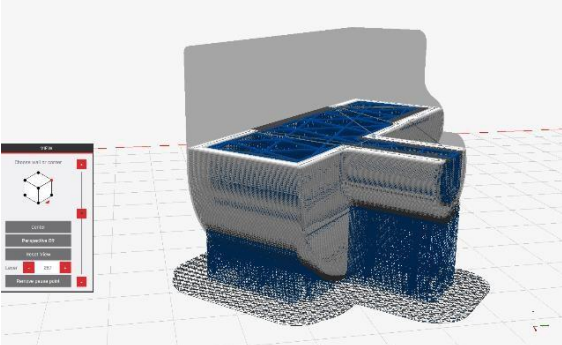
The breakaway and soluble supports have different properties. The choice of the suitable support material depends mainly on the geometry of the model. The advantages and disadvantages of breakaway and soluble structures are presented in Table 2. This summary will make it easier to select the right type of support material. When selecting the support structures, one should also take into account the type of printer owned and the currently available material combinations in the 3DGence Slicer software (Table 1).

Table 2 Advantages and disadvantages of breakaway and soluble supports

Breakaway support	Soluble support
Advantages	
<ul style="list-style-type: none"> the ability to print the model and supports only from one material, eliminating the need to use two different types of materials the printing time is shorter when using one type of material for the model and supports no need to have an additional device (i.e. station for dissolving supports) lower material costs shorter cleaning time for simple geometries 	<ul style="list-style-type: none"> a very small proportion of human labour and involvement from the user improved surface quality on the support side the possibility of making very complicated geometries (e.g. partially closed chambers or channels inside the model, thin-walled and openwork geometries)
Disadvantages	
<ul style="list-style-type: none"> difficulties in cleaning complex geometries time-consuming cleaning process requiring user involvement the risk of damage to the model geometry lower quality of supported surfaces 	<ul style="list-style-type: none"> the need for an additional device (station for dissolving supports) the need to prepare the solvent and its disposal at the end of the process longer time to clean the model from the supports

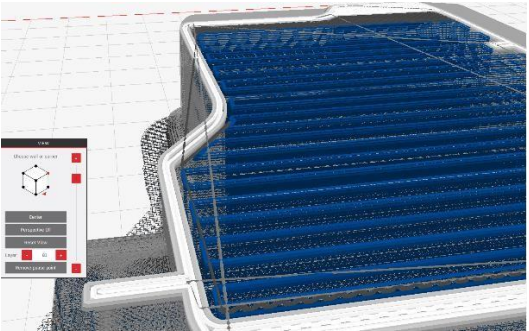
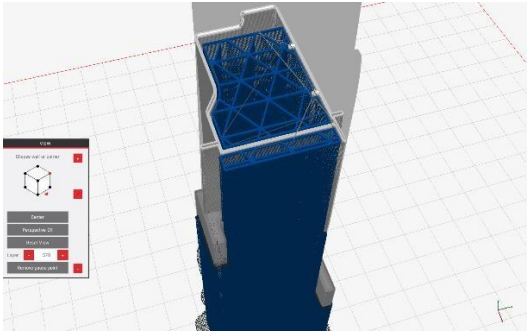
Depending on the complexity of the geometry of the model you want to print, it is possible to choose breakaway and soluble support structures. Table 3 shows examples of models where it is advisable to use breakaway supports and those for which soluble supports are a better choice.

Table 3 Types of geometry

Breakaway support	Soluble support
<ul style="list-style-type: none"> a straight body without the need for supports where the support is raft only 	<ul style="list-style-type: none"> openwork or very thin-walled model 
<ul style="list-style-type: none"> a space that needs to be supported and the support can be easily removed 	<ul style="list-style-type: none"> model with empty space inside and no access to the support (it is possible to rinse it out only) 

In 3DGence Slicer, it is possible to select the type of support structure - standard (rigid support: disabled) or reinforced (rigid support: enabled). The standard support is easy to remove as opposed to the reinforced, more difficult to remove support. Table 4 shows the use and advantages of both supports.

Table 4 Standard and rigid supports in 3DGence Slicer

Standard support (rigid support: disabled)	Reinforced support (rigid support: enabled)
Application	
<p>Recommended for simple geometries using breakaway support material</p> 	<p>Recommended when using soluble support material is used</p> 
Advantages	
<ul style="list-style-type: none"> supports very easy to remove reduced printing time lower material consumption 	<ul style="list-style-type: none"> much more stable support for slender and tall support structures higher reliability for complex geometries

3. BREAKAWAY SUPPORTS

The breakaway supports are a type of structures that must be removed manually. The use of suitable tools can significantly reduce the time needed to remove the support material. Examples of useful tools are shown in Fig. 5. However, it may turn out that standard tools are insufficient. In such a case, it will be necessary to make own, non-standard tools to better separate supports from the model, e.g. a flat screwdriver with a bent tip.

CAUTION: Special care should be taken when using tools.

In order to remove supports from the model:

- prepare the workplace,
- prepare tools,
- put on safety glasses,
- put on protective gloves,
- if possible, remove large parts of supports, bearing in mind the strength of the model (removing support structures as large elements is usually simpler than removing them in small parts),
- then gradually clean the model of the remaining smaller parts of the supports, taking care not to scratch or damage the model.



Fig. 5 Examples of tools

4. RINSE-OFF SUPPORTS

Support structures made of soluble materials enable the printing of complex geometries without the risk of damaging the model. They also allow for the execution of geometries in case of which it would be impossible to mechanically remove the breakaway support. 3DGence printers operate with two types of rinse-off supports. The support made of BVOH material is soluble in pure water, while the support printed from the ESM-10 material is soluble in aqueous solution. Rinsing out the ESM-10 material requires the use of an additional device, solvent preparation and subsequent disposal of the solution. The support material should be suitable for the model material. Possible material combinations with the use of soluble supports are presented in Table 5.

Table 5 Material combinations

Soluble support material	Compatible model materials	Solvent
BVOH	PLA, PET	water (22 °C – 50 °C)
ESM-10	ABS, PEEK	Solution of water with the VXL solve preparation (70 °C – 75 °C)

4.1. BVOH

4.1.1. Basic material data

BVOH (butenediol and vinyl alcohol copolymer) – water-soluble support material with highly hygroscopic properties. In a short time, it can absorb a large amount of moisture and water vapour from the environment. It works best with materials such as PLA and PET. It is a material sensitive to light and solar radiation. Basic technical data of BVOH filament are presented in table 6.

Table 6 BVOH technical data

Diameter	1.75 mm ± 0.07 mm
Net weight	0.5 kg
Nominal print temperature	210 °C
Density	1.14 g/cm ³

4.1.2. Required equipment

For the BVOH dissolution process, it is enough to obtain a sealed container made of stainless steel, plastic or glass with dimensions that allow for complete immersion of the rinsed off model. An example of a container is shown in Figure 6. The container should provide a sufficient level of safety, be properly described and ensure that plastic residues and sludge can be easily cleaned after the dissolution process. The optimal, but not the required solution will be to use the station to dissolve supports with heating and a mechanism supporting the process through forced circulation or ultrasounds, e.g. a dedicated station for cleaning the supports of the 3DGence Support Dissolving System as described in the following chapters.



Fig. 6 An example of a container for dissolving BVOH

4.1.3. Safety measures

Safety and first aid measures:

- In case of skin contact with dissolved material, rinse the contact area immediately with plenty of water. Then remove contaminated clothing and cover the skin with clean gauze. In addition, medical advice should be sought if there are changes in the appearance of the skin, irritating pain or discomfort.
- In case of contact with eyes, rinse the eyes immediately with plenty of running water.
- In the event of accidental ingestion of the material, seek medical attention immediately. Do not induce vomiting without a doctor's instruction.
- If you feel unwell, contact your doctor.

See the Material Safety Data Sheet for more information on safety measures and emergency first aid measures. The Material Safety Data Sheet (MSDS) of BVOH material is available at www.3dgence.com/support in the materials tab.

4.1.4. Dissolving process

The dissolution process of BVOH can be divided into four basic steps, which are described below. Before starting the process, ensure access to running water and get a suitable size water tank or a station for cleaning the models. During the dissolution process, avoid contact between the solution and the eyes and splashing yourself and the environment with water with the dissolved material. Also, do not drink water solution of BVOH. The dissolution time depends on the amount of support material to be rinsed out, water temperature and frequency of stirring and replacing the water.

The process of dissolution:

Step 1: Preparation:

- Prepare a tank that can accommodate a model or a purification station (e.g. 3DGence SDS as described in the following chapters). Make sure that the prepared tank or station is clean and free of residues of the previously used solution.
- Manually remove the raft and large and easy to tear off pieces of supports from the model – this will speed up the dissolution process of BVOH.
- Fill the tank or station with fresh water at 22 °C – 50 °C. If you have a device with a built-in heater, set the temperature to 50 °C.

Step 2: Immersion

- Immerse the model in the water tank so that it is completely below the water surface.
- Keep an eye on the dissolution progress. If you are not using the station, stir the water in the tank from time to time. If the solution is already cloudy and very viscous, replace it with fresh water – this will speed up the process.

Step 3: Rinsing

- When the dissolution is completed, remove the model from the tank/station and rinse thoroughly under running water. It is recommended to put on latex gloves before taking the model out of the tank.
- If remains of the non-rinsed support material remain on some of the model elements, rinse them again under running water, remove them mechanically or immerse the model in a clean water tank for some time.

Step 4: Drying

- At the end of the rinsing process, the model should be allowed to pre-dry for at least 15 minutes. In the case of a large amount of agent enclosed inside the model, you can place the model on a drip-top or paper towel, rotating every few minutes to allow the water to drain out of the model. This operation can be significantly accelerated by using a vacuum chamber.

4.1.5. Disposal of the solution

After completion of the dissolution process, the solution should be poured into the liquid waste installation in a concentration of not less than 20 parts by weight of water per part by weight of BVOH (i.e. > 20 cm³ of water per 1 g of BVOH), maximum of 2 kg of BVOH per day. However, it should be verified that the procedure described is in accordance with local regulations.

4.1.6. Use and storage of material

The BVOH material should be printed:

- in an environment with humidity below 40%,
- When printing in a high humidity environment, use a material dryer or, for the 3DGence INDUSTRY F340 printer, store the material in a dedicated filament chamber.

If the printer does not have a dedicated filament chamber, due to the properties of BVOH, the following should be done after the end of the printing process:

- discharge the filament by selecting from the printer menu: Materials → Unload support material and follow the instructions on the printer display,
- store the filament in a tightly closed container with moisture absorbers.

When printing from damp material, there may occur:

- problems with lamination of layers,
- characteristic foaming of the material,
- repeated errors of the filament flow control system (Material T1 feed malfunction detected message).

In case of damp material:

- it should be dried in an environment with the lowest possible humidity and a temperature of 40 °C – 50 °C for 12 hours,
- the drying process should be carried out using an industrial dryer, a filament drying device or, in the case of the 3DGence INDUSTRY F340 printer, a dedicated filament chamber,
- in a dedicated filament chamber, set the temperature to 40 °C, place the filament in it and leave it for 12 hours without opening,
- if you do not have access to the above-mentioned devices, you can heat up the printer's work table to 50 °C, place the filament on it and leave it for 12 hours. Before leaving the filament, disable the "sleep mode" option.

Note: Damp material in which the individual filament fibres on the reel are stuck together is not re-usable and must be disposed of.

4.2. ESM-10

4.2.1. Basic material data

ESM-10 is an aqueous solution soluble support material for professional use. The filament is characterized by high chemical compatibility and adhesion to ABS and PEEK material. This makes it possible to print the ESM-10 with the above-mentioned model materials. In addition, its properties enable the support structure to be stable when operating in a heated chamber, the temperature of which can be above 80 °C. The material ESM-10 is compatible with the industrial 3DGence INDUSTRY F340 printer, and its basic technical data is presented in Table 7.

Table 7 Technical data of EMN-10

Diameter	1.75 mm ± 0.05 mm
Net weight	750 g
Nominal print temperature	250 °C
Density	1.14 g/cm ³

4.2.2. Required equipment

For the process of dissolving the ESM-10 material, we recommend using the 3DGence Support Dissolving System flowing station (Fig 7). The station is made of high quality stainless steel. The insulation materials used inside the tank maintain a constant temperature, which makes it very efficient. The device is equipped as standard with a semi-automatic filling and emptying system, filling level sensor (min, max), safety switch, work cycle programmer, temperature controller and wheels to facilitate movement. In the 3DGence Support Dissolving System (3DGence SDS) it is possible to submerge a model with the dimensions of the 3DGence INDUSTRY F340 printer's working area. Additionally, during the process of dissolving the support material, there is no degradation of the target model. Technical data of 3DGence Support Dissolving System are presented in Table 8.



Fig. 7 Support cleaning station of the 3DGence Support Dissolving System

Table 8 Technical data of the 3DGence Support Dissolving System

Power supply	220 – 240 V AC
Rated current	10 A
Heaters (power)	1 x 240 V (2000 W)
Tank capacity	55.2 l
Operating temperature range	ambient temperature – 90 °C
<i>External dimensions of the device</i>	
Height	1270 mm
Length	530 mm
Depth with rear connections	640 mm
<i>Dimensions of the inner tank</i>	
Height	360 mm
Length	360 mm
Depth	280 mm
<i>Available connections</i>	
Electric	Cable 2.5 m, CEE 7/7 compliant plug (type E, F)
Water supply connection	pipe 1.5 m, connector 1 inch, internal thread
Water drain connection	pipe 1.5 m, rubber connector 25 mm

4.2.3. Safety measures

Safety and first aid measures when using ESM-10 material, VXL solve preparation and prepared water solution with VXL solve:

- In case of skin contact, rinse the contact area immediately with plenty of cold water. Then remove contaminated clothing and cover the skin with clean gauze. In addition, medical advice should be sought.
- In case of contact with eyes, rinse the eyes immediately with plenty of running water. Seek medical attention if irritation develops.
- In case of ingestion of ESM-10 material or solution, rinse your mouth with water, induce vomiting immediately and seek medical attention.
- In case of ingestion of VXL solve powder, do not induce vomiting, do not administer milk and alcoholic beverages. Gently wipe and rinse the inside of the mouth. Seek medical attention.
- If you feel unwell, contact your doctor.

For more information on safety measures and ad hoc measures for first aid, please refer to the Material Safety Data Sheet of ESM-10 and VXL solve. MSDS cards are available at www.3dgence.com/support in the materials tab.

Additionally, when using the 3DGence Support Dissolving System and the water solution with VXL solve:

- Follow the 3DGence Support Dissolving System User Manual and observe the safety rules contained therein.
- Wear splash-proof safety glasses.
- Use rubber gloves that are resistant to high temperature solution, preferably protecting as much of the forearm as possible.
- Local safety regulations must be observed.
- Do not put your hands into a tank filled with hot solution.
- Do not turn on the unit's heaters without water or solution in the tank.
- Before removing any residual material from the tank, remove the basket from the unit.

Additional recommendations are available in the 3DGence Support Dissolving System manual at www.3dgence.com/support in the instructions tab.

4.2.4. Preparation of the solution

To prepare the solution in which the ESM-10 material will be dissolved, VXL solve powder is needed. The 3DGence Support Dissolving System has a capacity of 55.2 litres, which means that 1440g of VXL solve have to be poured into a full water tank. Table 9 shows the required amount of powder for solution preparation depending on the amount of water in the tank.

Table 9 Required number of VXL Solve depending on the size of the tank

Amount of water	Amount of VXL solve
15 l	360g
25 l	720g
55.2 l (3DGence SDS)	1440g
120 l	2880g

The prepared solution should be replaced from time to time. Table 10 shows the efficiency of the solution depending on its amount in the tank. In the prepared solution in the 3DGence SDS device, a maximum of 1,450 g of ESM-10 material can be dissolved. If this amount is exceeded, the solution must be disposed of. The need to replace the solution will be further indicated by a noticeable decrease in the intensity of dissolution of the ESM-10 filament.

Table 10 Solution efficiency

Solution quantity	Maximum quantity of ESM-10 material to be dissolved in the prepared solution
15 l	350 g
25 l	720 g
55.2 l (3DGence SDS)	1450 g
120 l	2900 g

A detailed instruction manual for 3DGence Support Dissolving System is available at www.3dgence.com/support in the instructions section. Before operating the device, please read the manual. The following is a shortened procedure for the preparation of the solution.

ATTENTION: Before proceeding with the solution preparation process, personal protective equipment must be ensured, e.g. glasses, latex gloves, plastic apron, dust mask.

Solution preparation procedure in the 3DGence Support Dissolving System:

1. Make sure that all control valves are in the correct position.
2. Make sure that the water inlet and outlet pipes are properly connected.
3. Connect the device to the mains power supply.
4. Turn on the device (the switch is located on the right side of the device).
5. Open the top cover.
6. Check that the filter at the bottom of the tank is correctly installed (see 3DGence Support Dissolving System User Manual for more information).
7. Press and hold the "tank fill" button until the tank is full. Once the water has reached its maximum level, the filling process is stopped and no more filling is possible. The water level in the tank will be 55.2 litres.
8. Wear personal protective equipment, especially rubber gloves and goggles.
9. Slowly pour the powder into the water in the tank. The container should be filled with 1440g of VXL Solve powder.

Attention: The solution may foam. If a large amount of foam appears, stop pouring in, wait until the foam disappears and then continue. The powder should be poured in slowly from a small height (about 3 cm above the water surface) and should not be inhaled.

10. Close the top cover to start the machine without printing for a few minutes.
11. Set the temperature to 70 °C. The temperature can be set in the "temperature programmer" panel by pressing the "set" button and then using the up and down arrows.
12. Turn on the heaters by moving the "heater" switch to the "on" position.
13. Switch on the pump by moving the "pump" switch to the "on" position.
14. Set the operating time to 5 min. The operating time can be set in the "time programmer" panel by pressing the "set" button and then using the up and down arrows.
15. Start the program by holding the up arrow in the "temperature programmer" panel under which the word "start" is displayed.
16. When the cycle is complete, a beep sounds and the blue "program end" LED lights up:
 - proceed to the next chapter, which describes the dissolution process,
 - in case the device will not be used immediately after preparation of the solution, switch off the heaters, the pump and the unit.

4.2.5. Dissolving process

Before proceeding with the process of dissolving the ESM-10 material:

- prepare the 3DGence SDS device according to the user manual available at www.3dgence.com/support in the instructions tab,
- prepare a water solution with VXL solve (the process described in chapter 4.2.5),

- manually remove the raft and large and easy to tear off pieces of supports from the model – this will speed up the dissolution process.

The temperature at which the dissolution process should be carried out should be in the range of 70 °C – 75 °C. The dissolution time of the model is influenced by factors such as the geometry of the model and the amount of support material used, which must be washed out, the shape of the support, the method of dissolution, the water temperature and the degree of use of the solution. It is therefore difficult to clearly and precisely determine the dissolution time of the ESM-10 material. Approximate dissolution times are shown in Table 11.

Table 11 Indicative dissolution times of ESM-10

Weight of support structures	Dissolving time
< 50 g	6 h
50 – 200 g	10 h
> 200 g	16 h

ATTENTION: Before proceeding with the dissolution process, personal protective equipment must be ensured, e.g. glasses, rubber gloves, protective apron.

Process of dissolving EMS-10 support structures in 3DGence SDS:

- Open the top cover.
- Put on personal protective equipment, especially rubber gloves and goggles.
- Place the model in the tank.
- Close the top cover.
- Set the temperature to 70 °C. The temperature can be set in the "temperature programmer" panel by pressing the "set" button and then using the up and down arrows.
- Switch on the heaters and the pump in case they have been switched off.
- Set the working time to the value of the estimated time needed to dissolve the supporting structures (Table 11). The operating time can be set in the "time programmer" panel by pressing the "set" button and then using the up and down arrows.
- Start the program by holding the up arrow in the "temperature programmer" panel under which the word "start" is displayed.

At the end of the program:

- A beep sounds and the blue "program end" LED lights up:
- Turn off heaters, pump and device.
- Put on personal protective equipment, especially latex gloves and goggles.
- Open the top cover.
- Pull out the tank and lock in the top position, so that the solution drains from the model.
- Check that all fragments of supports have been dissolved.
 - If so, go to rinsing and drying the model (chapter 4.2.6).
 - If not, place the model back in the tank and run the program for a few hours more, then check again that the supports have been completely rinsed out.

4.2.6. Rinsing and drying of the model

After the dissolution of the ESM-10 material has been completed, the model should be allowed to pre-dry for at least 15 minutes. In the case of a large amount of agent enclosed inside the model, you can place the model on a drip-top or paper towel, rotating every few minutes to allow the water to drain out of the model. This operation can be significantly accelerated by using a vacuum chamber.

The next step is to rinse the model thoroughly from the remaining agent. It is recommended to rinse the model under running water at 30 °C – 60 °C and then leave it to dry completely.

If there's a problem with the white coating on the surface of the model, immerse the print in the water for at least an hour. To speed up the effect, you can prepare a water solution with rinse aid for dishwashers and soak the model in it for about an hour.

If a white coating is observed during the next dissolution process:

- check if a large amount of agent is inside the model, in this case it is recommended to use a longer pre-drying time, or drying in a vacuum chamber (if it is possible),
- check that the solution has been properly prepared and that too much material has already been dissolved in the solution.

4.2.7. Disposal of the solution

The used solution should be poured out into the liquid waste disposal installation. If the unit has a connection for liquid waste disposal, use the tank emptying function (see 3DGence SDS user manual for more information). However, please check with your local regulations that your waste water service provider allows this. Table 12 shows a comparison of the pH of the different agents and it follows from the comparison that the pH of the prepared water solution from VXL solve is practically the same as the pH of the washing powder solution or dishwasher detergent.

Table 12 Comparison of the pH of different agents

Product	PH value
Freshly prepared solution of the dissolving agent	10 to 11
Washing powder solution	11 to 12
Dishwasher detergent solution	10 to 11
Typical household cleaners	9 to 12

4.2.8. Station cleaning

If after completion of the model flushing process it is not planned to use the station for the next few days:

- remove the solution from the tank,
- for 3DGence SDS with direct connection to the water and sewerage system, remove the solution from the tank using the operator panel (see 3DGence SDS user manual for more information),
- rinse the tank several times with clean water,
- turn the power off via the main power switch or disconnect the power cord.

4.2.9. Storage of material

The ESM-10 material should be stored in a dedicated heated filament chamber of the 3DGence INDUSTRY F340 printer. The purpose of the chamber is to keep the filaments in a high temperature environment, which prevents moisture, change of parameters and dimensions of the material. The printer's main power supply should be turned on for the chamber to be heated.

In view of the properties of the ESM-10, if the printer is switched off using the main switch for a longer period of time (the material chamber is not powered), after the printing process is completed:

- discharge the filament by selecting from the printer menu: Materials → Unload filament and follow the instructions on the printer display,
- store the filament in a tightly closed container with moisture absorbers.

When printing from damp material, there may occur:

- problems with lamination of layers,
- characteristic foaming of the material,
- repeated errors of the filament flow control system (Material T1 feed malfunction detected).

In case of damp material:

- it should be dried in an environment with the lowest possible humidity and a temperature of 40 °C – 50 °C for 12 hours,
- the drying process should be carried out using an industrial dryer, a filament drying device or, in the case of the 3DGence INDUSTRY F340 printer, a dedicated filament chamber,
- in a dedicated filament chamber, set the temperature to 40 °C, place the filament in it and leave it for at least 12 hours without opening.



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